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REVISED REPORT

(NASA-CR-151495) IDENTIFICATION OF CROPS IN CENTRAL ARKANSAS USING VISUAL AND INFRARED SPECTRAL REFLECTANCE SIGNATURES (Arkansas Univ., Pine Bluff.) 12 p HC A02/MF A01 CSCL 02C G3/43

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IDENTIFICATION OF CROPS IN CENTRAL ARKANSAS USING VISUAL AND INFRARED SPECTRAL REFLECTANCE SIGNATURES

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IDENTIFICATION OF CROPS IN CENTRAL

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ABSTRACT

In recent years, there has been an increasing concern with the implementation of land use and resource management plans at various governmental levels. These plans are critically dependent on rapid and synoptic acquisition of inventory and classification data. Remote sensing techniques with aircraft or satellite mounted sensors appear to offer the best means of obtaining these data. Preliminary results of ERTS-I experiments have demonstrated the ability to classify agricultural crops by spectral reflectance signatures. However, temporal signatures are found to be equally important in the identification process. Thus, the spectral signature of each crop must be calibrated for differing environments and for discrimination from differing backgrounds.

This project was designed to calibrate the spectral reflectance signatures of the principles crops of Central Arkansas (cotton, soybeans, rice). Data was collected by conducting ground based reflectance signatures at well controlled test sites. However, data collected is primarily for soybeans and additional measurements are essential to the acquisition of significant results.

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RESEARCH DESIGN

INTRODUCTION

The primary objective of this project was to address the problem of inventory and yield estimation of the principal crops grown in central Arkansas (soybeans, cotton, and rice). This objective was to be realized by obtaining well calibrated ground measurements of the spectral reflectance of the principal crops of central Arkansas. A secondary objective was to analyze sequential ERTS-I images of the same or similar crop acreages (selection to be compatible with ERTS resolution).

Specific objectives of the research program were as follows:

A. To obtain spectral reflectance measurements in four ERTS-I MSS bands throughout the growing season for controlled plots of cotton, soybeans, and alfalfa at the University of Arkansas at Pine Bluff Agricultural Test Sites. In addition, measurements were to be taken in the immediate vicinity of the test sites of both these crops and rice under normal field conditions.

B. An aircraft flight by one of the instrumented NASA/JSC aircraft was to be requested over the region during the conduction of the ground measurement program. The data acquired by this flight would have a resolution compatible with the test plot size and would permit direct extension control from the controlled sites to normal fields in the immediate vicinity.

C. Data acquired was to be used to develop spectral and temporal signatures for the major crops in the region (soybeans, cotton, rice and alfalfa). These signatures would be used to interpret ERTS-I imagery obtained during the growing season throughout central and eastern Arkansas. The prinicpal objectives of the interpretation were to be on discrimination, identification, and acreage estimation. A secondary objective would include correlation of the calibration signatures with resulting data to estimate the productivity of identifiable blocks.

APPARATUS AND EXPERIMENTAL PROCEDURE

All apparatus essential to the acquisition of the necessary data was fabricated from off-the-shelf materials.

The primary apparatus components were a ERTS Ground Truth Radiometer Model 100 manufactured by Exotech, Incorporated and a 4 ft. x 8 ft. x 0.063 in. Reflectance Panel.

The Model 100 Radiometer is specially designed to supply an ERTS experimenter with either airborne or manually obtained Ground Truth data which matches spatially and spectrally the ERTS Multi Spectral Scanner (MSS) data. The instrument utilizes the four Spectral filters employed in the Space Craft System to provide four simultaneous channels of accurately calibrated radiometric data of both down welling (incident) and reflected radiation - manufacturers description. The spectral bands are four channels reproducing the ERTS MSS band passes (0.5 to 0.6 microns; 0.6 to 0.7 microns; 0.7 to 0.8 microns; and 0.8 to 1.1 microns). Glass absorption filters are used to correct the silicon detectors to simulate the ERTS photomultiplier response curves. Thin film filters are added to reproduce the ERTS band passes.

The Reflectance Panel was designed so that the complete 2π steradian radiometer field of view for measuring downwelling (incident radiation) of the radiometer was totally spanned from a projection height of 10 ft. It was adjudged that this projection height was adequate to provide a plant canopy of sufficient magnitude to obtain spectral reflectance signatures characteristic of the plant specimen alone. A tripod camera mounting was affixed horizontally to the apex of the 10 ft. ladder to provide a stable mounting for the radiometer (also, used for camera mounting) and to facilitate position orientation.

Three primary test sites were chosen, one for each of the major crops of interest (cotton, soybeans, rice and alfalfa). The soybean test sites were located at the UA-PB Agriculture Experimental Demonstration Farm. The cotton and rice test sites were located in areas east of the city of Pine Bluff within a distance of eight (8) miles of the UA-PB campus.

The cotton and rice field test sites were homogeneous; (i.e. uniform fertilization, and treatments). Consequently, design configurations for these crops were of the type characteristic of Arkansas farm lands.

For the soybean test site a Latin Square design, as related to fertilization treatment, was utilized.

The radiometric measurements for soybeans were taken at forty different staked sites. These measurements were taken over a time period from June 12, 1975 to July 22, 1975. Also, readings were taken in the summer of 1974. Pictures were taken of plant canopies at stake locations which correspond to the radiometer measurements. Plant heights during the periods that data was collected ranged from 15 cm to 98 cm.

To facilitate the comparison of data acquired with other studies, dimensionless variables were utilized, i.e., all radiometric measurements refer to the ratio of the magnitude of the reflectance signature of the plant canopy to that of the Reflectance Panel. A typical data sheet utilized for recording pertinent variable is found in Appendix I.

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RESULTS AND DISCUSSION

It was readily apparent, as initial radiometric readings were taken, that the research objectives would be very difficult to realize utilizing the restricted resources and inexperienced personnel available. Additionally, several variables which had not been anticipated in the research design proved to be dominant factors. Inclement weather was a major deterrent to the acquisition of data on a periodic schedule. High density cloudiness before and after a rain interlude coupled with muddy field conditions precipitated logistic and instrumentation problems which prevailed.

The test sites chosen for cotton and rice, presented data acquisition problems which were not anticipated and which the investigators could not resolve. Primarily the location of the test sites relative to the base of operations presented a logistic problem which inhibited the collection of data in an organized and scheduled manner. Consequently, because of time restraints, data collection was restricted to soybeans.

A summary of the data collected during the peak soybean growing period; the months of June and July, 1975; appears in Table I. Each datum point represents an arithmetic time average of all readings taken at the particular site location. The heights of the soybean plants under dry conditions ranged from 15 cm to 98 cm.

Since it was observed that several uncontrollable variables (cloudiness, wind, etc.) influenced the radiometric readings, dimensionless variables were utilized throughout.

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TABLE I

TABLE OF DIMENSIONLESS
REFLECTANCE MEASUREMENTS IN THE
FOUR ERTS-I MSS BANDS

Site Locations	Channel Number I	Channel Number II	Channel Number III	Channel Number IV
I	0.10	0.08	0.41	0.51
II	0.08	0.08	0.35	0.42
III	0.11	0.08	0.35	0.66
IV	0.07	0.04	0.44	0.64
V	0.08	0.06	0.46	0.67
VI	0.06	0.08	0.38	0.46
VII	0.08	0.06	0.41	0.50
VIII	0.04	0.04	0.49	0.57
IX	0.05	0.05	0.48	0.68
X	0.08	0.07	0.38	0.47
XI	0.08	0.08	0.40	0.54
XII	0.10	0.07	0.41	0.50
XIII	0.05	0.06	0.38	0.52
XIV	0.07	0.06	0.38	0.71
XV	0.06	0.09	0.37	0.58
XVI	0.08	0.05	0.48	0.59
XVII	0.06	0.10	0.50	0.67
XVIII	0.08	0.09	0.39	0.68
XIX	0.08	0.08	0.46	0.98
XX	0.08	0.07	0.46	0.57
XXI	0.07	0.04	0.51	0.66
XXII	0.06	0.04	0.41	0.56
XXIII	0.08	0.11	0.45	0.60

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XXIV	0.06	0.04	0.42	0.71
XXV	0.08	0.06	0.49	0.74
XXVI	0.06	0.06	0.52	0.57
XXVII	0.05	0.04	0.35	0.52
XXVIII	0.07	0.04	0.33	0.50
XXIX	0.06	0.06	0.46	0.67
XXX	0.07	0.06	0.42	0.55
XXXI	0.07	0.14	0.34	0.57
XXXII	0.08	0.07	0.29	0.44
XXXIII	0.07	0.04	0.42	0.56
XXXIV	0.05	0.05	0.44	0.44
XXXV	0.10	0.08	0.47	0.65
XXXVI	0.05	0.05	0.43	0.57
XXXVII	0.04	0.05	0.39	0.51
XXXVIII	0.06	0.05	0.36	0.53
XXXIX	0.06	0.06	0.43	0.51
XXXX	0.10	0.09	0.41	0.60

Channel Number I	Channel Number II	Channel Number III	Channel Number IV
(0.5-0.6 microns)	(0.6-0.7 microns)	(0.7-0.8 microns)	(0.8-1.1 microns)

An analysis of the dimensionless tabular measurements yield the following results:

Channel	Range	Time Average
I	0.04 - 0.11	0.07
II	0.04 - 0.14	0.06
III	0.29 - 0.52	0.42
IV	0.42 - 0.98	0.58

While these quantitative features give some indication of the reflectance signatures of soybeans at specified test sites, it would be hazardous to extrapolate these results to other sites over a wide area. However, relative signature values for the four ERTS -I MSS bands should be valid within acceptable experimental error standards.

Although there are inherent experimental difficulties associated with the acquisition of Ground Truth data, it appears reasonable that the dimensionless variable approach to the problem provides a logical and less cumbersome experimental technique.

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APPENDIX I

DATA SHEET

Investigator _____

Field Plot No. _____ Date _____

Crop _____ Time _____

Weather Cond. _____ FOV _____

Film _____ Film _____

Roll _____ Roll _____

Number _____ Number _____

Film Speed _____ Film Speed (ASA) _____

F-Number _____ F-Number _____

Shutter _____ Shutter _____

Camera Setting _____ Camera Setting _____

	TARGET		CALIBRATION PANEL	
Channel	Gain	Reading	Gain	Reading
1.				
2.				
3.				
4.				

COMMENTS:

EQUIPMENT PURCHASED
NSG 9002

ITEM (Vendor)	COST	DATE ORDERED	DATE RECEIVED
10 ft. Aluminum Ladder (Butt Building Materials Company)	$63.35	6/11/74	6/11/74
3 ft. Gate Table (Magic Mart)	$16.48	6/11/74	6/11/74
4' x 8' x 0.063" Aluminum Sheet (Pine Bluff Trailer Mfg. Co.)	$43.00	5/30/74	5/30/74
Minolta Camera (Magic Mart)	$259.00	5/28/74	5/30/74
Tripod Camera Mounting (Magic Mart)	$16.97	5/28/74	5/30/74
2 Four Post Tracing Tables (Charles Bruning Co.)	$350.00	5/3/74	10/16/74
Radiometer (Exotech Inc.)	$2,600.00	5/6/74	10/20/74

EQUIPMENT BORROWED (Lyndon B. Johnson Space center)

ITEM	DATE RECEIVED	DATE RETURNED
Radiometer	7/2/74	11/19/74
White Reflectance Panel	7/2/74	11/19/74

No inventions or patients have been obtained as a result of this project.

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